DOCUMENT RESUME

ED 219 637 CE 033 429

AUTHOR Mishler, Glenn; Spignesi, Bill
TITLE Conversion of Gasoline Engines to Use Ethanol as the Sole Fuel. Student Guide.
INSTITUTION State Fair Community Coll., Sedalia, Mo.
PUB DATE [80]
NOTE 18p.; For a related document see CE 033 428.

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Auto Mechanics; Behavioral Objectives; *Engines; *Fuels; Learning Activities; Learning Modules; Secondary Education; Trade and Industrial Education
IDENTIFIERS *Engine Modification; *Ethanol

ABSTRACT

This student guide is a learning packet that is intended for use as part of the regular auto mechanics curriculum and that provides the information necessary to convert a gasoline engine with a minimum of modifications to successfully be operated on ethanol alcohol. Contents include an introduction, objectives, procedures, list of tasks to be performed, activity sheet, and information sheets with photographs and diagrams. (YLB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

- ✓ This document has been reproduced as received from the person or organization originating it.
- ☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

D LUND

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

STUDENT GUIDE

CONVERSION TO ETHANOL FUEL

INTRODUCTION

The anxiety over accessibility of world oil supplies in recent years has renewed interest in possible use of domestic ethanol alcohol as a motor fuel. Research carried out at SFCC in 1980 yielded a system which makes it possible to operate existing internal combustion engines on ethanol as the sole fuel. This program is designed to provide information necessary to convert an engine with a minimum of modifications to successfully be operated on ethanol alcohol as the sole fuel.

This program is intended for use as part of the regular auto mechanics curriculum. No basic engine or fuel system theory will be present, only components affected by the conversion to ethanol fuel will be included.

Some basic material may be included for reference purposes.

OBJECTIVES

1. Compare the characteristics of gasoline and ethanol as motor fuel.

2. Explain the problems involved in using ethanol in an engine designed to run on gasoline.

3. Explain adjustment and modification necessary to compensate for ethanol fuel.

4. Demonstrate how to fabricate parts needed to modify carburetor venturi to vaporize ethanol.

5. Describe how to check ethanol to determine proof value.

PROCEDURES

1. Read the objectives and introduction to this module.
2. Study the information sheets which are part of this learning packet.
3. Complete the activity sheets which are part of this learning packet.
4. Review the objectives to be certain you understand what you are expected to have learned. Performance of these objectives will be evaluated of the post test.
5. When you are satisfied that you have satisfactorily completed the tasks on the activity sheet ask your instructor to evaluate your performance.

PERFORM THE FOLLOWING TASKS:

1. Disassemble the carburetor and construct the venturi sleeves using the instructions contained in this module.
2. Install the sleeves and re-assemble the carburetor.
3. Install the carburetor on the engine and run engine on ethanol making the necessary adjustments for the best performance.

ACTIVITY SHEET

ENGINE CONVERSION TO ETHANOL

Instructions: Complete the questions and laboratory activities on this activity sheet. You may refer to the information sheets while completing this exercise.

1. In a short paragraph explain the effects on the carburetor fuel metering system when the venturi diameter is changed. _____

_____

_____

_____

_____

2. In order to get acceptable performance and economy from a vehicle operating on ethanol an average air-fuel ratio of about _____ is required.

3. Anhydrous or neat alcohol is pure. If it is rated as 190 proof it means it contains _____.

4. With respect to fuel the octane rating indicates. _____

_____

5. The most difficult problem to overcome in using ethanol as fuel in a low compression engine is: _____.

6. Comparing ethanol to gasoline as a motor fuel, ethanol contains about _____ as much heat as gasoline.

Ask your instructor for access to a training engine or vehicle and the necessary tools and supplys to convert the unit to operate on ethanol.

The problem of getting an engine designed to operate on gasoline to run on ethanol requires an understanding of the basic differences in the two fuels.

An internal combustion engine is a heat engine. The heat value of a gallon of gasoline is about 124,800 Btu while for ethanol it is about 84,400 Btu. Gasoline vaporizes at 140° to 160° F, kerosene at 250° to 400° F, while ethanol vaporizes at 180° to 200° F. The flash point of gasoline is -50° F, alcohol 70° F, the auto ignition temperature for gasoline is 495° F, for alcohol 685° F.

Some other comparisons are presented in the appendix.

A few important differences require consideration when substituting one fuel for the other. The air fuel ratio for gasoline is 14.2-15.1 in most stock carburetors. Ethanol requires an air fuel ratio of 9.0-1.

Alcohol is much more difficult to vaporize than gasoline. It requires 900 Btu to vaporize 1 gallon of gasoline and 3,378 Btu to vaporize 1 gallon of alcohol. When gasoline is vaporized as in a carburetor, the mixture will be about 38° F cooler than the liquid and air before vaporization Alcohol will have a temperature drop of 143° after vaporization.

The net effective calorific value of alcohol is very nearly 70 per cent that of gasoline. This includes the latent heat of evaporation of the fuel and not that of the water formed in the combustion. The thermal efficiency with which alcohol is used in an engine at any compression ratio is always somewhat greater than that with which gasoline is used in the same engine, due allowance being made for different requirements in a fuel ratio.

At a low compression pressure, suitable for use with gasoline, the power output of a given engine is about 10 to 20 percent greater with alcohol as the fuel, and the specific fuel consumption of the alcohol is about 40 percent greater than that of gasoline. The increase in power output is to a large extent, due to the higher latent heat of the alcohol, as compared with gasoline. The alcohol which produces a greater lowering of temperature upon evaporation. The result is a cooler denser air fuel mixture, and a greater charge of air and fuel is taken into the cylinder during the intake stroke.

The vapor pressure of alcohol is lower than gasoline, and the latent heat of evaporation is higher. As a result it is harder to start a cold engine on alcohol than on gasoline.

The most practical way to overcome this problem is to devise some type of priming system to inject gasoline into the engine for cold starting.

Engine operation is smoother and steadier on alcohol than on gasoline. This characteristic has been called the "steam engine" effect. The engine shows an ability to operate under heavy load and at low speed, with full throttle, without "bucking" which characterizes similar conditions with gasoline as the fuel. It has been thought that a slightly lower rate of flame propagation may in part, account for this result.

Alcohol burns in an engine without leaving a residue of carbon. In addition, alcohol acts as a solvent for the binder in the carbon deposit left by the combustion of gasoline and, therefore, serves to loosen such carbon accumulation.

The products of combustion of alcohol in an engine are essentially the same as those from the combustion of gasoline, but the carbon monoxide content is lower. The flame temperature, with alcohol as the fuel, is appreciably lower than with gasoline.

Alcohol has a higher density, lower fluidity, and requires a lower air-fuel ratio (richer mixture) than does gasoline. Hence, to adapt a gasoline engine to burn alcohol some modifications of the carburetor systems must be accomplished.

From the preceding information, it can be seen that alcohol is, in many respects, an excellent fuel for spark ignition motors. The low vapor pressure and high latent heat causing cold starting difficulties is somewhat offset by the fact that alcohol and air form combustible mixtures over a wider range of concentrations than does gasoline. These same properties make alcohol a safer fuel to handle. Alcohol mixes with water in all proportions, so that alcohol fires are readily extinguishable by water. It is evident, that alcohol, or blends consisting principally of alcohol, cannot be used interchangeably with gasoline, although such fuels may be very satisfactory in engines designed to use them.

The heat content of a fuel is not of itself of great importance, but taken in conjunction with thermal efficiency, it gives a measure of fuel consumption. The heat contents of the correct air-fuel mixtures are practically the same for most fuels, about 80 Btu per cu. ft. The latent heat of evaporation is an important factor in carburetion. The correct air-fuel mixture, with alcohol is 143° F colder than the original air and fuel, while the corresponding value for gasoline is only 38.8° F and a blend of 20% alcohol and 80% gasoline results in a 55.6° temperature drop. The cooler air-fuel mixture obtained with alcohol results in a denser charge entering the cylinder.

In the carburetor, the fuel and air are so proportioned as to produce a mixture which gives as complete combustion as is consistent with good performance.

The air-fuel ratio can be varied, and the effect of such variation upon power and economy is accepted. The air-fuel ratio required for alcohol is about 60% that for gasoline. Since air-fuel ratios are affected by the density and humidity of the air, it is not possible to make very fine adjustments. The usual practice is to use a lower air-fuel ratio, that is a richer mixture, than the most economical one.

In the automotive engine, the air-fuel ratio must be varied to adjust for changes in engine speed and temperature. Alcohol forms explosive mixtures over a much wider range of proportions that does gasoline. The air-fuel ratio has a very great influence upon the degree of completeness of combustion. The lower the air-fuel ratio, the greater the carbon monoxide content of the exhaust gases.

It is highly desirable that neither the fuel nor its products of combustion have a deleterious effect upon any part of the engine or fuel system. The products of combustion of a hydrocarbon or of an alcohol are acidic, and are therefore somewhat corrosive. This condition is particularly pronounced when low air-fuel ratios are used, and is believed that much excessive wear of the upper part of the cylinder bore is due to the use of too rich mixture. The products of combustion of alcohol are the same as those of gasoline, and the exhaust gases are no more corrosive. Gasolines may sometimes contain amounts of sulfur and cause corrosion due to the formation of sulfuric acid. Alcohol contains no such corrosive materials. The gums formed by gasoline are soluble in alcohol, and are removed from the walls of tanks which have previously contained gasoline.

If large amounts of gum or residue are present, particles are loosened and collect in fuel filters or screens. Special accomodation should be made for this situation during early stages of converting to alcohol fuel.

In summary, alcohol would seem to be an acceptable fuel. Some increase in consumption is in part offset by greater thermal efficiency, a slight increase in power, smoother operation and lower operating temperatures. The conversion to alcohol fuel requires overcoming the difficulty in vaporizing the alcohol in the carburetor. The Spignesi-Mishler system to achieve this is next presented.

THE SPIGNESI - MISHLER SYSTEM

After some experimentation with enlarging carburetor jets and so on, as employed by most gasoline to alcohol conversion methods, it was abandoned in favor of modification of the air flow system. The reason for this change was the fact that the liquid systems in the carburetor are precisely calibrated by the manufacturer and are independent of operator control. Air flow, which determines the speed and power output of the engine, is under the control of the operator and can be varied under a wide range of speed and load requirements without upsetting the basic function of the carburetor.

The desired results can be achieved by concentrating on the air flow in the venturi, while at the same time leaving the liquid system intact. By installing a sleeve in the venturi there will be a slight increase in the restriction of the air flow. This increase in restriction will cause an increase in velocity of the air passing through. The higher velocity of the air will achieve better vaporization of the alcohol and will result in a change in the air fuel ratio from 15 to 1 to about 9 to 1.

The success of the conversion can be noted by checking the temperature of the carburetor base while the engine is operating. Considerable lowering of temperature should be evident. Some frost may appear at times. If there is not evidence of these conditions and engine performance is not satisfactory the thickness of the material used in making the sleeves may need to be adjusted. The vehicles used in our experiments required .032 thick aluminum for the sleeves. This resulted in a 12 per cent reduction in the area of the venturi. Vehicles of other displacement and carburetor configuration may require different thickness for the sleeves. This can be determined by trial and error until satisfactory engine performance is achieved.

The following pages contain detailed instructions on making the sleeves. Care must be taken not to obstruct any discharge ports or air bleed orifices in the venturi area. Holes can be drilled in the sleeve to relieve these openings.

Instructions are also included for a gasoline priming system. For a vehicle operating in various temperatures and weather conditions it would be desirable to construct this system to insure ease in starting under all conditions.

Fig. 1 Venturi Sleeve Patterns

Pattern for venturi sleeve is first made of paper. Use venturi of carburetor to be converted as guide.

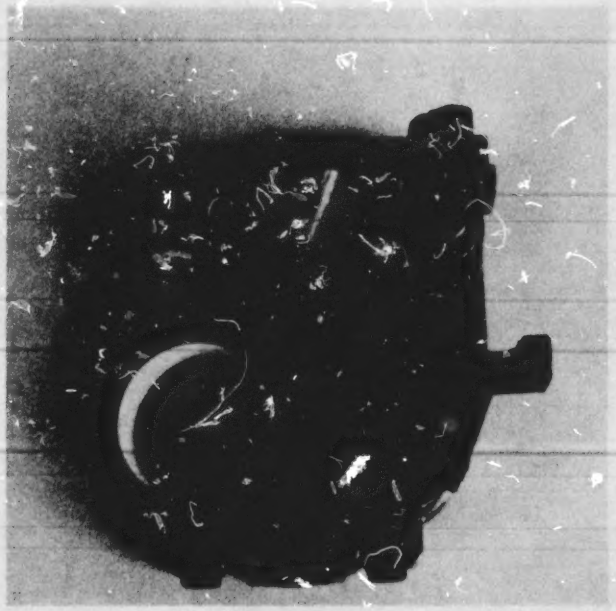


Fig. 2 Paper Pattern in Venturi

Trim pattern until satisfied with fit in carburetor venturi.

Fig. 3 Fitting Aluminum Sleeve to Carburetor

Cut out aluminum sleeve using paper pattern as guide. Again trim aluminum sleeve until satisfied with fit.

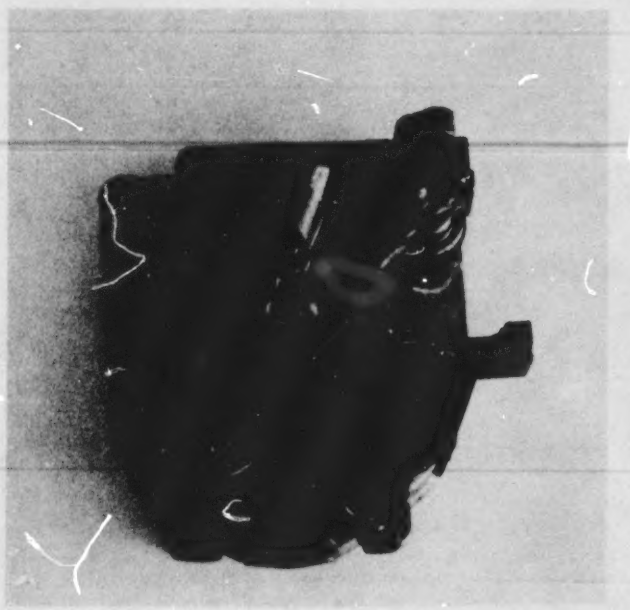


Fig. 4 Aluminum Sleeve in Venturi

Aluminum sleeve should fit with bottom flush with surface, ends fit together and top should extend about 1/8" above top of venturi.

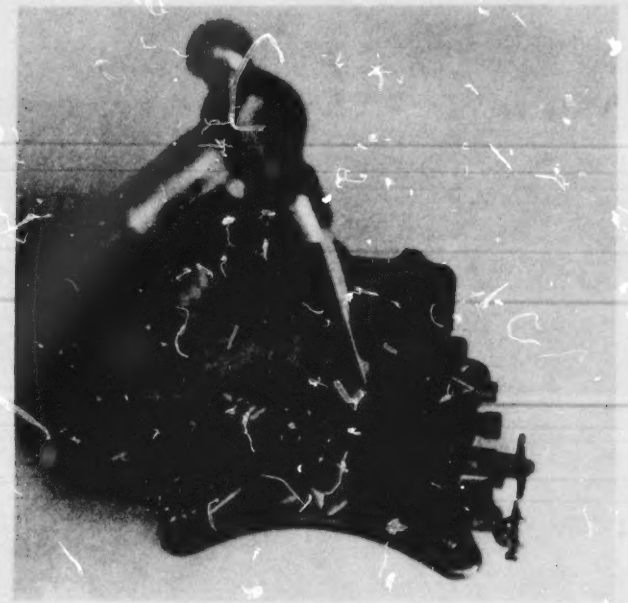


Fig. 5 Forming Top of Sleeve

Top of sleeve should be bent over using a pin punch forming them to the shape of the top of the carburetor venturi.

GASOLINE INJECTION SYSTEM

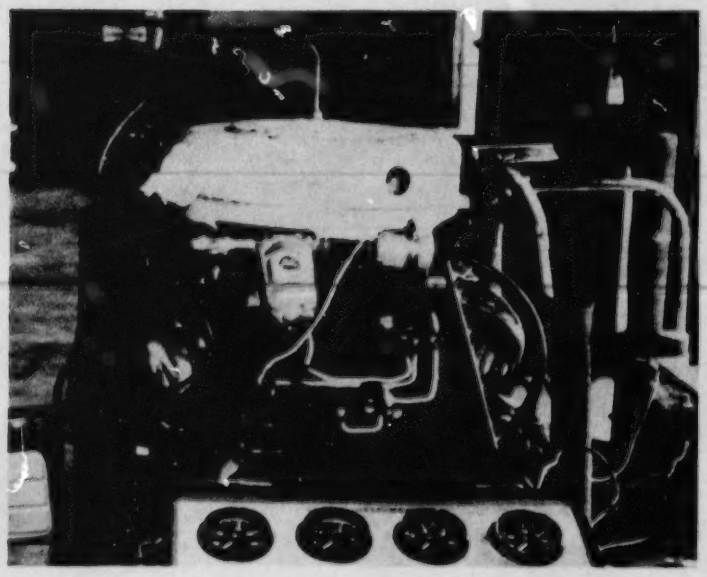
To prevent starting difficulty, particularly in cooler weather, it is recommended some type of gasoline injection system be installed.

The system shown consists of a small engine fuel tank attached to an electric fuel pump with a fuel filter between. A line running to the air filter injects gasoline through a tube with an orifice directly into the air horn of the carburetor. The control system consists of a horn button wired to a horn relay to the pump. An oil pressure switch teed into the output line wired to an indicator light, serves to signal when gasoline is being delivered to the carburetor air horn.

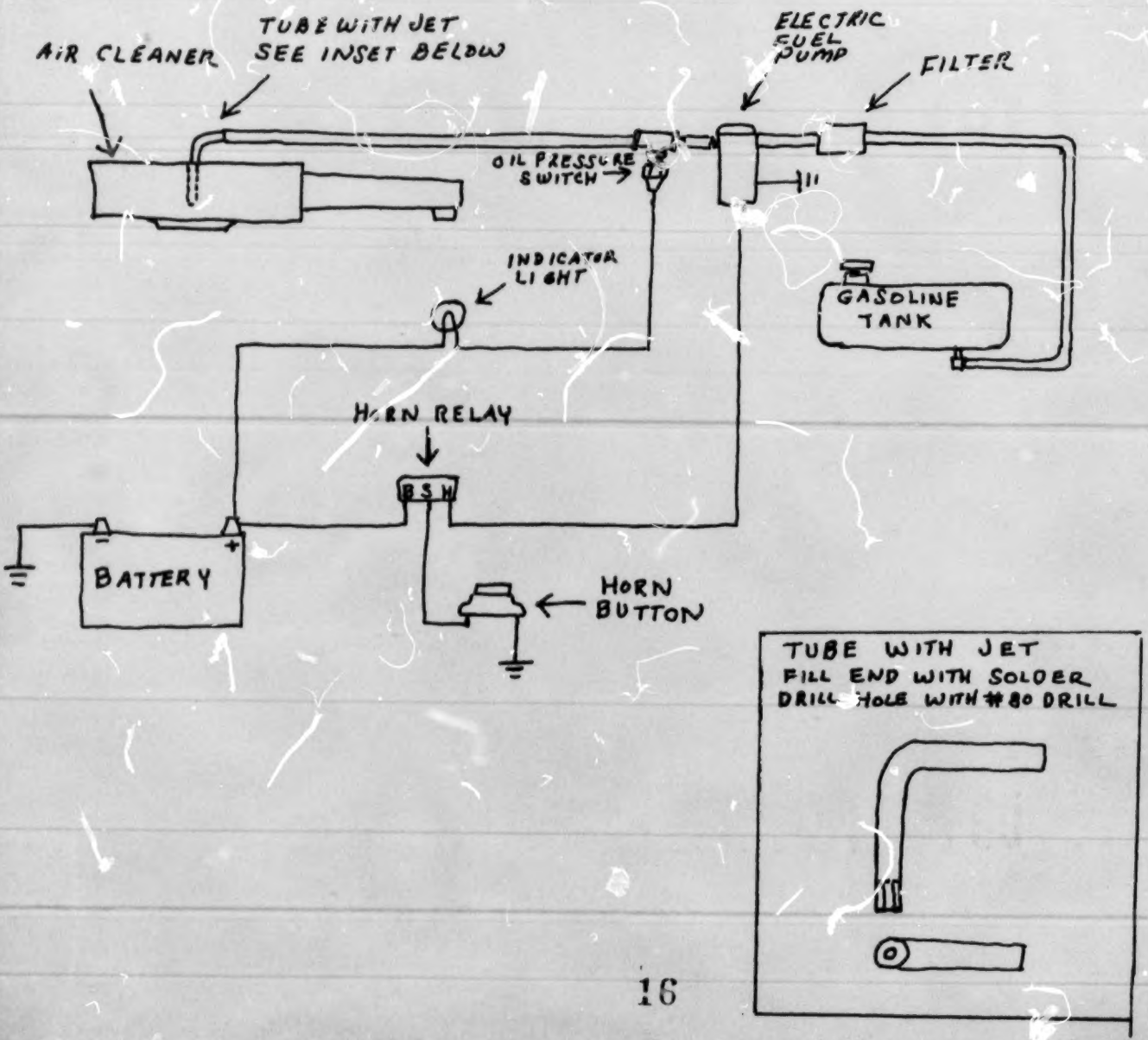
A list of the parts required and construction details can be found on the following pages.

PARTS LIST

1. Electric Fuel Pump
2. Horn Relay
3. Horn Button
4. Oil Pressure Switch
5. Indicator Light
6. In-line Fuel Filter
7. Small Fuel Tank (1 gallon or less)
8. 1/8" x 2" Pipe Nipple
9. 1/8" Pipe Tee
10. 1/4" Fuel Hose
11. 10" of 1/4" Steel or Copper Tube
12. 16 Ga. Primary Wire
13. No. 80 Twist Drill (.013)



GASOLINE INJECTION SYSTEM DIAGRAM



PROPERTIES OF ETHANOL, GASOLINE AND WATER

CHEMICAL PROPERTIES	Gasoline	Ethanol	Water
Formula	C_4-C_{12}	CH_3CH_2OH	H_2O
Molecular Weight	varies	46.1	18.015
% Carbon (by weight)	85-88	52.1	
% Hydrogen (by weight)	12-15	13.1	
% Oxygen (by weight)	indefinite	4.7	
C/H ratio	5.6-7.4	4.0	
Stoichiometric Air-to-Fuel Ratio	14.2-15.1	9.0	

PHYSICAL PROPERTIES	Gasoline	Ethanol	Water
Specific Gravity	0.70-0.78	0.794	1.0
Boiling Point (^{o}F)	80-440	173	212
Freezing Point (^{o}F)	-70 approx.	-173	32
Viscosity at 68^{o}F (cp)	0.288	1.17	1.0

THERMAL PROPERTIES	Gasoline	Ethanol	Water
Heating Value			
Btu/lb at 68^{o}F	20,260	12,800	
Btu/gal	124,800	84,400	
Heat of Vaporization			
Btu/lb	150	396	940
Btu/gal	900	3,378	7,802
Octane Ratings			
Research	91-105	106-108	
Pump (Ron + Mon)/2	86-90	98-100	
Flammability Limits (% by volume in air)	1.4-7.6	4.3-19.0	
Specific Heat (Btu/lb - ^{o}F)	0.48	0.60	1.0
Autoignition Temperature (^{o}F)	430-500	685	
Flash Point (^{o}F)	-50	70	

CONVERSION FACTORS

1 gallon gasoline = 6.2 pounds per gallon
1 gallon water = 8.33 pounds (at 60°F) = 0.134 cubic foot = 128 fluid ounces = 4 quarts = 8 pints = 3.785 liters
1 gallon of ethanol weighs 6.6 pounds
1 barrel of crude oil = 42 gallons
1 Btu = 252 calories = heat required to raise 1 lb of water 1 degree Fahrenheit (°F)
1 bushel = 56 pounds
1 calorie = .00397 Btu = heat required to raise 1 gram of water 1 degree Centigrade (°C)
1 U.S. liquid gallon = 4 quarts = 231 cubic inches = 3.78 liters
8 gallons = 1 bushel
1 liter = 1.057 U.S. liquid quarts
1 fluid ounce = 30 milliliters
1 pound = 453.6 grams
1 cubic foot = 7.48 liquid gallons = 62.36 pounds H_2O (at 60°F)
1 acre = 43,560 square feet = 4,840 square yards
To convert from °F to °C, subtract 32 and then multiply by 5/9.
To convert from °C to °F, multiply by 9/5 and then add 32.